

stage to a pustular or pemphigoid eruption. Gussenbauer reported an urticaria following a septic gangrene of the lower leg, in which many of the lesions were transformed into vesicles containing bloody fluid. Bamberger was one of the first to report a case of pyemic pemphigus; since his publication the condition has been rarely seen, and only in cases of severe septicemia. When the eruption is vesicular the vesicles may arise from urticarial or ecchymotic spots, and may develop into pustules followed by ulceration. In a remarkable case reported by Unna the eruption was pock-like.

6. *Herpes*. Herpes labialis does not appear to have been a particularly frequent feature of pyogenic septicemia, to judge from the reported cases. This is rather surprising when one considers its frequency in diseases like typhoid fever, the exclusion of which from septicemia is purely a matter of nomenclature. Herpes labialis does, of course, occur in pyogenic septicemia; the statement that it is more common in toxic than septic conditions is probably in part due to the fact that when this has been the only cutaneous lesion present the case has not been considered interesting enough to report, and therefore has not gotten into the literature.

CONCLUSIONS DERIVED FROM FURTHER EXPERIENCE IN THE SURGICAL TREATMENT OF BRACHIAL BIRTH PALSY (ERB'S TYPE).

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In 1905 Clark, Taylor, and Prout published¹ "A Study on Brachial Birth Palsy." The clinical portion of the study was based upon 7 operative cases. Since that time 36 additional cases have been operated upon, making 43 altogether. These have varied in age from four weeks to nineteen years.

Owing to the long lapse of time between the operation and the appearance of the end results in these as in many other cases of nerve suture (often two to three years) it has not been possible to follow many of the series as systematically and persistently as would be desirable for satisfactory case reports. Nevertheless the frequent operative contact with these lesions, the prolonged struggle involved in the after-treatment, and the constant con-

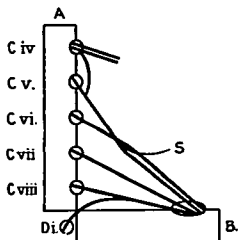
¹ AMER. JOUR. MED. SCI., October, 1905.

sideration of the problems involved have led to certain convictions which are worth presenting for discussion to those interested in this subject.

As to etiology there is no question that the chief factor lies in the forcible separation of the head and neck from the corresponding shoulder, whether it occurs through too forcible instrumental traction when the shoulders are impeded, or whether the head and neck are used to pry out the shoulder from under the pubis, or whether, in a breech, too great traction is put upon the shoulders for the delivery of the after-coming head.

A few mild cases of the palsy have occurred where spontaneous delivery has relieved both instruments and accoucheur of any participation as active etiologic factors. Such cases should render us loath to put the responsibility in any given instance upon the accoucheur, yet nevertheless he, by a proper grasp of the mechanics of the thing, can nearly always avoid doing, and can often prevent Nature from doing, what would tend to cause this very serious lesion. If any obstetrician will make a simple apparatus like Fig. 1 he can readily work out the essence of the etiology.

FIG. 1.—Schematic representation of brachial plexus. A, spinal column; B, shoulder; S, supra-scapular nerve; C_{iv} to D_i, roots of plexus. If A and B are pulled away from each other C_{iv} and C_{vi} would first be put on the stretch. After they had yielded C_{vii} would be involved, and so on down the line. S, the supra-scapular nerve, would always be damaged first and most. If A and B are approximated the roots are relaxed, or if they have been torn the ends would be approximated. This should be the aim of treatment in all fresh cases.



In the original study only extraspinal lesions were considered. These, in brief, consist of rupture of the deep cervical fascia lying in front of the roots of the plexus, of rupture of the perineural sheaths, and finally of the nerves themselves, together with the vessels of all three structures. The resulting mass of torn fibrous tissue, nerves, vessels, and blood-clot organizes into a firm cicatrix which does not permit the passage of nerve impulses. The roots usually rupture in order from above downward, and the lesion involves one or more or all of them according to the degree of force used in causing the injury.

In addition to these extraspinal injuries there have undoubtedly been intraspinal lesions much more frequently than had been supposed. Where the roots are torn from the cord, hemorrhage occurs and the organization of the clot later causes cicatricial

deformity of the corresponding portion of the cord. This type of injury has been demonstrated by Dr. George Boyer, of Toronto,² in the case of a woman, aged forty years, who had borne such an injury through life.

It is not possible to state, with proof, that both extraspinal and intraspinal lesions occur in different roots of the same plexus, but the findings in certain of the cases operated upon most strongly indicate that such is the fact. For instance, in one of the late cases of the series there was a typical palsy of the upper arm type, fairly good motion about the elbow-joint, and complete flaccid paralysis of the hand, with marked atrophy of its intrinsic muscles. On dissection there was the usual cicatrix in the fifth and sixth roots extraspinally. The condition of the hand meant a serious lesion of the eighth cervical and first dorsal roots, but these, extraspinally, appeared undamaged, and on splitting their sheaths showed normal appearing fasciculi. There must therefore have been intraspinal damage to the two lowest roots of this plexus.

As previously stated the damage nearly always extends from above downward in the order of the roots, and involves from one to all the roots according to the degree of force used in causing the injury.

The damaged area in any given root may lie at any point between the spinal cord and the place where the final nerve trunks are given off from cords of the plexus. The lesion may consist of a circumscribed cicatrix involving a part or the whole of the root at any part of its course, or of several cicatrices scattered along its course, or of one large cicatrix involving practically the whole root. One cicatrix may involve two neighboring roots, this being commonly the case with the fifth and sixth roots, or may involve all the roots of the plexus when it has suffered complete rupture.

One or more of the roots may be completely torn across, the ends widely separated and grown fast to neighboring structures by scar tissue.

In all these cases the layer of deep cervical fascia lying just in front of the nerve roots is torn and always becomes adherent to the underlying nerves in the healing process. In certain rare cases the deep fascia alone is injured, adheres to the underlying nerves, and by cicatricial compression interferes with their functional activity.

With the exception of the intraspinal lesions, which could not be demonstrated anatomically, my series of 43 operative cases has illustrated each of the types above mentioned, and if one's operative experience were sufficiently extensive, he might expect to see an example of every type mathematically possible.

When the lesion is intraspinal, or when the cicatrix involves the

² *Pro. Royal Soc. Med.*, 1911 (Neurological Section), v, 31 to 56.

root well into the intervertebral canal, operation as at present performed offers little prospect of improvement. Whether some modification of procedure will benefit these cases remains to be seen. Implantation into a neighboring root has been tried in a recent case, but there has not been sufficient time for results to appear.

Following permanent interference with nerve function, certain secondary pathologic changes develop, the importance of which was not appreciated fully until after a considerable experience with the postoperative treatment of these cases, and which have a most decided bearing upon determining at what age surgical interference should be insisted upon. The bones of the extremity do not develop normally. The clavicle is small, the scapula is small, the coracoid process is often drawn downward and forward, forming a beak which interferes with free mobility of the joint, and the glenoid process maintains its infantile form. The upper end of the humerus remains infantile, and this, together with a similar condition in the glenoid process, renders easy the posterior dislocation seen in a certain proportion of these cases, which will be referred to later in dealing with symptomatology.

Constant maintenance of the elbow- and wrist-joints in the faulty positions characteristic of these cases causes the plastic bones of infancy to develop in somewhat abnormal shapes in their joint ends. Moreover, contractures in the paralyzed muscles and in the ligaments about the joints serve still further to fix and accentuate the deformities of the extremity as time goes on.

Thus the characteristic deformity seen just after birth is a purely functional one, and is due to the muscular imbalance resulting from the paralysis of certain groups of muscles. When, however, the paralysis persists through the early months or years of rapid growth the deformity, at first functional, becomes fixed mechanically by the organic secondary pathologic changes above enumerated. If late surgical intervention succeeds in obtaining good nerve regeneration, and this is usually the case, there still remain as serious obstacles to free motion these organic structural changes which enormously increase the period of postoperative treatment and prevent the attainment of a completely satisfactory ultimate result.

From this description of the incidence and sequence of pathologic events in these cases it is self-evident that in the great majority of instances there will be permanent interference with the transmission of nerve impulses in greater or less degree, and this degree will depend upon the number of roots torn and upon the distribution and extent of the resulting cicatrices. Inasmuch as the roots are almost always injured one after the other in order from above downward the muscles paralyzed naturally fall into the groups related to the primary roots of the plexus for innervation.

The great majority of the cases are of the "upper arm type," in which the injury involves the fifth and sixth roots. These two roots join soon after their exit from the intervertebral foramina, and this junction, which is often 1 cm. or more long, again divides to form trunks which enter into the plexus. From the outer edge of this junction is given off the suprascapular nerve. Injury to these roots is usually at their junction, or just above it, or at and just below it. In a smaller proportion of cases they are damaged at or within the intervertebral foramina, and rarely torn from the cord itself.

A study of the schematic plexus, Fig. 2 (Kocher), will indicate better than much description the muscle groups related to the different nerve roots and what must be the result of different root injuries.

While the schematic plexus is not accurately drawn a study of it will show how one may get some approximate idea of the situation of the lesion from the grouping of the symptoms. The branches to the deep muscles of the neck as well as those forming the posterior thoracic nerve come from the roots soon after their exit from the intervertebral foramina, so that if the rhomboids, the scaleni, and especially the serratus magnus are paralyzed one may deduce that the lesion extends up to if not into those foramina.

The more common lesion occurs distal to the origin of these branches, so that the winged scapula significant of serratus paralysis is not so frequently seen.

The usual picture in the newborn child is that of a complete flaccid paralysis of the extremity which lies close along the side with the elbow and wrist straight and the fingers somewhat flexed. There is marked inward rotation of the entire extremity, with pronation of the hand. This total paralysis results from the fact that those nerves which have not been torn and permanently injured have been overstretched and temporarily paralyzed.

In the not rare cases where the entire plexus is ruptured this clinical picture is permanent. In the less severe cases the lower roots begin to functionate, so that after days or weeks, as the case may be, motion begins to appear first in the fingers, then in the hand, wrist, forearm, etc., up to the level of the permanent lesion. In still slighter cases these motions in the distal portions of the extremity may be present from the start.

As time goes on the permanently paralyzed muscles undergo contracture and cause the typical deformity seen in Fig. 3; they also atrophy. This atrophy is not so easily made out in the young infant because of the thick layer of subcutaneous fat which keeps the form of the extremity filled out.

In certain of these cases there develops after a time a posterior luxation or subluxation of the shoulder-joint. This results from a combination of factors. The complete paralysis of the spinati

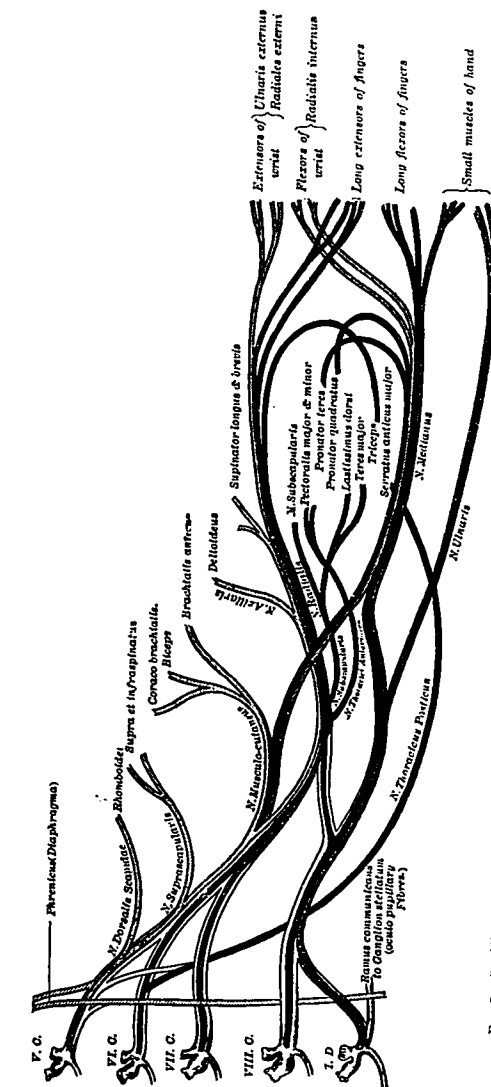


FIG. 2.—Semi-diagrammatic scheme (Kocher) to show the formation of the brachial plexus and the nerve supply to the muscles of the upper extremity.

and deltoid leaves the posterior and external aspects of the joint without the usual muscular support. The persistent infantile shape of the glenoid fossa and the end of the humerus favor easy dislocation. The pectoralis major, being usually only partially paralyzed, strongly rotates the humerus inward and exerts some pressure backward upon it. When the subscapularis, teres major, and latissimus dorsi escape partially or wholly from the paralysis they add much to the inward rotation and posterior displacement of the upper end of the humerus.



FIG. 3.—Typical deformity in a late case. Note the small size of the entire extremity, the marked inward rotation and pronation, the flexion at the elbow, the marked flexion, and ulnar adduction at the wrist.

This posterior displacement occurs in greater or less degree in every case, and can be made out readily by careful comparison with the opposite normal shoulder. The extreme degree of this displacement results in complete posterior luxation. When the biceps and coracobrachialis suffer from contracture there is an added upward thrust to the head of the humerus which brings it well up under the acromion process.

In the literature these complete posterior dislocations not infrequently appear under the title of "Congenital Posterior Dislocation of the Shoulder." One Boston, one Philadelphia, and one

New York case are on record in which operative procedures upon the shoulder-joint itself were done, with the idea of reducing the dislocation. In one of the three where reduction was impossible the head of the humerus was resected.

The histories, the pictures of the characteristic attitudes of the extremities, and the results in these cases leave practically no doubt that they were really examples of brachial plexus injury at the time of birth. These cases accent the necessity of the surgeon's associating a neurologist with himself in the care of these obscure congenital deformities about the shoulder-joint.

From infants it is practically impossible to derive any satisfactory information as to sensory disturbances in these arms, and by the time they are old enough to examine satisfactorily, sensory disturbances have disappeared except possibly in the cases of severe injury where some hypesthesia or anesthesia may persist.

There is regularly interference with the growth of the extremity.

One symptom which was worked out by Clark and presented in the original study is not sufficiently comprehended and appreciated. Careful palpation of the region of the fifth, sixth, and seventh transverse processes invariably makes out a characteristic induration which varies with the severity of the lesion, and which is always sensitive to pressure. The examiner should approach the sitting child from the rear and palpate both sides of the neck at the same time to compare the normal with the damaged side.

This induration seems to be less marked in those cases where the roots have apparently been pulled from the cord.

The meat of this problem lies in the question of prognosis in these cases when they are not treated surgically. Upon a proper conception of the prognosis must depend the system of treatment which will lead to the best ultimate results.

Most text-books give an optimistic prognosis. For instance a well-known pediatric text-book says: "The great majority of cases recover spontaneously in two or three months, improvement being observed within a few weeks. Spontaneous recovery is not to be looked for unless it occurs within the first three months. Not infrequently some degree of paralysis persists until the third or fourth year, and in some of the muscles, especially the deltoid, it may even be permanent."

A well-known text-book on neurology says: "Many of these cases go on to spontaneous recovery within six months after birth. Others remain longer and do not recover within the first year. The condition may remain for three or four years and pass away only when the child is old enough to be taught systematic gymnastic exercises."

These quotations are evidently optimistic. As a matter of fact in all these unfortunates (except where the entire plexus has been

ruptured) spontaneous improvement appears after an interval of three to twelve weeks after birth and continues slowly until the child is about two years old. After this time improvement ceases and the pathologic sequels previously mentioned cause increasing deformity and interference with function.

This long period of time over which spontaneous improvement occurs is to my mind the chief cause of the firmly fixed but entirely erroneous belief with regard to the prognosis in these cases. The mothers take their infants to the clinics, are told that the outlook in most instances is good, and are invited to come regularly for manipulation and electricity. After a time improvement sets in and progresses steadily. After a further interval, pressed by other demands upon her time and relieved of her mental anxiety by the prognosis of ultimate spontaneous recovery, the mother ceases to attend the clinic. The physician, looking over his records, and remembering the continuous improvement over a period of time, attributes the further non-attendance to spontaneous recovery. If, however, he would visit any of the orthopedic dispensaries he would find many of these children applying for treatment at a time when the mothers had given up hope of the recovery which had been held out to them in the infancy of the victims.

Recently a child, one year old, was brought in by its mother. It had a marked paralysis still persisting with absolute flaccid paralysis of the wrist and hand. Yet when this child was only three months old he was taken to one of our well-known neurologists, who examined him and then told the mother to rub the arm, put it through passive motions for the joints, and it would come around all right. The hopelessly crippled extremity at the end of a year led the mother to consult an orthopedic surgeon, who referred him for immediate operation. At operation C VI, VII, VIII, and D I were completely torn across and regeneration could never have occurred.

This kind of history is repeated again and again in our operative cases, and this attitude on the part of the profession at large does more than anything else to prevent these unfortunate cripples from obtaining the best treatment at the best time.

Let me say, with as much emphasis as possible, that my personal experience convinces me that the prognosis in these brachial injuries is exceedingly bad; that complete spontaneous recovery is rare, occurs only in mild cases, is complete usually by the end of three months, and almost never later than six months. In the vast majority of cases there will be a permanent defect.

Until the true prognosis permeates the general profession the surgical repair of these lesions will never have its best opportunity, and anyone who follows these cases for a sufficient length of time will become convinced that surgery alone holds out the best hope to the great majority of them.

Having arrived thus far the one great thing is to choose the best time for operative interference.

It is generally admitted that nerve generation and regeneration are most active in young infants.

Here as elsewhere in the peripheral nervous system the sooner a divided nerve is sutured end to end the better is the prospect of a satisfactory result.

Within a few weeks or months of birth the secondary pathologic changes previously enumerated begin to develop, causing a mechanical fixation of the extremity in its deformed attitude. The longer this fixation has persisted the more tedious will be the after-treatment.

From the above premises the only logical deduction would be immediate operation. However there are some reasons for temporary delay. It is unwise to subject a newborn babe to anesthesia until it has had a short time to adjust itself to its new surroundings and to show how competent its digestive apparatus is to be.

The damaged tissues should have time to regain their normal resistance to infection. Instead therefore of demanding immediate operation, which would be best from the standpoint of nerve repair, we must demand operation at the earliest feasible moment considering the general condition and the local resistance of the individual child. Under these circumstances the choice of time for operative interference may vary from two weeks to three months. Seldom will it need to be postponed beyond three months.

It will be noted that in laying down the indications for operation nothing has been said with reference to spontaneous regeneration and recovery. The plan of waiting until spontaneous improvement has ceased is the greatest imaginable stumbling block in the way of obtaining the best results in this whole class of patients, for the reasons mentioned under "secondary pathologic changes." In all cases where a really complete spontaneous recovery will occur the primary paralysis will be of only moderate degree and obvious improvement will begin within the first couple of weeks. In every case where there is considerable paralysis and where no improvement begins within the first few weeks there is certain to be some degree of permanent injury to the roots.

In every case where this permanent injury is indicated, and in every case where it is even debatable whether permanent injury has occurred, operation at the earliest feasible moment, as above indicated, should be performed.

In these operations the chief risk lies in the anesthetic, because the wound goes only through skin and fatty tissues; with experience the loss of blood may be limited to one or two teaspoonfuls; the shock is negligible, and the time consumed varies with the complexity of the lesion found.

In the debatable cases the procedure might better be called an

exploration rather than an operation. If no lesion demanding nerve resection and suture be found the wound is promptly closed and the whole thing is over in fifteen minutes, with no chance of harm to the child. It amounts to nothing more than the making and closing a skin incision, which permits inspection and palpation of the roots, with precise knowledge upon which to found the after-treatment for the individual case.

If on the other hand a definite lesion is found it is resected and followed by end-to-end suture, and this is done at the time which is obviously the best for the child's future.

The newborn victim of this injury is caused to suffer much pain and detriment because of the advice commonly given to the parents—namely, "to start at once with massage, passive motion, and (possibly) electricity."

One should remember that the original injury starts a traumatic neuritis, which is aggravated by massage and passive motion, especially about the shoulder region. This added irritation causes more scar tissue to interfere with nerve regeneration. Moreover, the victim is caused an unnecessary amount of pain.

In all these cases the best primary treatment would be to keep the injured extremity at rest for at least two weeks. This might best be done with an ordinary triangular sling so arranged as to derive all its support from the sound shoulder and to cause marked elevation of the shoulder on the damaged side. This method obviously removes all strain from the plexus, and, in case any of the roots are torn, approximates the ends and gives the best opportunity for spontaneous repair.

At the end of two weeks the sling may be removed daily and gentle massage given, always with care not to pull the shoulder away from the head and neck, as this would again stretch the damaged nerves.

At the end of three weeks decision should be made for or against operative exploration, and, if operation is chosen, it should be done as soon as the particular child can stand it.

Some variations from the operative technique published in the original study may be worth mentioning.

In extensive lesions the incision there described, running from the lower third of the sternomastoid to the outer third of the clavicle, gives the best working exposure. For less extensive cases, and in young children where the tissues are elastic, an incision from the insertion of the sternomastoid running outward and slightly upward, following the natural wrinkles in the skin at the base of the neck, will give a satisfactory exposure, and heals with a scar that will never spread. The first incision heals by primary union satisfactorily, but later always spreads into a broad, flat, white scar, which is objectionable in females.

Where there will be tension on the nerve suture, silk is the preferred material. In young infants in whom the working space and the nerves are small, and where there is less likelihood of much tension on the sutures, a purse-string suture of fine chromic catgut answers.

In infants a few weeks old the dissection is comparatively easy because the scar tissues have not become firm and the nerves are readily identified. Apposition is also easier.

The older the child the firmer the scar tissues become, and the more difficult is the dissection. In some of the older cases, where some of the roots have been torn completely across, the ends displaced and later bound by firm adhesions to neighboring structures, a field for dissection is provided in which the greatest patience, endurance, and skill in anatomical orientation is requisite to ravel out the mysteries contained in the blanket of scar tissue.

In those cases where a root or roots have been torn from the cord they must be anastomosed into a neighboring root, with the hope of getting a distribution of power. This procedure has been done within the last few weeks in a child and in an adult after an avulsion of the C VIII and D I from the cord.

When the nerve sutures are placed, and if there is more than one they must all be placed before any of them are tied, the head, neck, and shoulder are approximated. This position must be maintained without a moment's relaxation. The sutures are tied from below upward, the skin wound is closed with silk, a sterile dressing applied, and appropriate fixation accomplished. This fixation apparatus must hold the head and shoulder in close approximation without a moment's cessation for from three to twelve weeks from the time of operation, according to the individual case.

In the early cases a plaster splint, fashioned before operation, was used, but it proved not only to be heavy, clumsy, and uncomfortable, but, worst of all, after ten days became so limp as no longer to maintain the necessary position.

A steel brace was then devised (Fig. 4), and this has served its purpose without undue discomfort to the patient. In the case of young children, when it is properly applied, it permits free handling for bathing and dressing, and is not much in the way of the clothing.

The brace is made of flat steel rod appropriately bent and supplied with supports for the forearm and shoulder. A muslin cap is fitted to the child's head, the edges of which are turned up over the head part of the brace (Fig. 5). This prevents the head from protruding too far through the brace. An adhesive plaster strap is started from the top of this cap, passes down the cheek of the well side, and across under the chin to the shoulder pad of the brace. The shoulder pad, which overlies the scapula of the damaged extremity, is fastened by a broad adhesive strap which passes from

the pad obliquely downward over the child's back (Fig. 6). The forearm and arm are bandaged to the brace.



FIG. 4.—Steel brace, showing grooved channel for the forearm and hand, a large pad to hold the shoulder forward, and the upper curved band to encircle three-quarters of the head. The whole thing is padded and covered with leather.



FIG. 5.—The brace applied, elevates the whole extremity so as to approximate the shoulder to the neck. The upper part, with a muslin cap stitched to it, holds the head down and to the damaged side. The chin strap prevents the child from getting its head out from under the brace. The shoulder pad, fitting over the scapula, holds the shoulder from being displaced backward. The net result is to hold the child fast with the head and neck and shoulder closely approximated so as to relieve the strain on the nerve sutures. This position is the one that should be adopted in every fresh case so as to approximate the damaged nerve ends and give the best chance for spontaneous healing.

This brace must be carefully fitted and adjusted before operation, or pressure sores are apt to develop and complicate the postoperative treatment.

Many parents and even practitioners express the fear that wry-neck will follow the prolonged fixation of the neck. In my whole series of cases that complication has not appeared a single time.

The after-treatment is an exceedingly important part of the care of these children. It starts with the removal of the brace, and at first should consist of massage and passive motion applied to the fingers, hand, wrist, forearm, elbow, and muscles of the arm. For an interval of four to six months after the operation, manipulation about the base of the neck and shoulder should be used with great care to avoid putting strain upon the sutured nerve roots. For the same reason such manipulation as is given to the remainder of the extremity should always be conducted in a way not to pull the shoulder away from the neck or downward.



FIG. 6.—Showing the posterior view of the brace, with a broad band of adhesive plaster running from the shoulder and obliquely down across the back. The cap, which was just pinned on for the picture, has become distorted in the child's wriggling.

Electricity, while not essential, is of some value, and often helps to keep the parents at systematic treatment.

After sufficient time has elapsed for absolutely firm union to have occurred in the sutured roots, manipulations about the shoulder should be more vigorous. The greatest difficulty to overcome lies in the contracted pectoralis major and the shortened anterior capsule of the joint. It may be necessary to stretch them under an anesthetic or to lengthen the pectoralis tendon. These troubles ensue only in the cases which have been too long neglected before operation.

As the evidences of nerve regeneration appear the child must be educated to use the muscles, heretofore functionless, by means

of gymnastic exercises, games, workshop methods, etc. These methods must be followed systematically for several years to get the best results after operation.

The first question asked always is, What are your results?

To allay any suspicion of overenthusiasm or radicalism I may state frankly that I never have seen a perfect arm result from operation nor do I ever expect to. There is always failure to reach perfect function to a greater or less degree.

On the other hand in the great majority of cases there will result a degree of improvement which can be attained by no other method than the surgical repair of the damaged nerve roots. Several of the series operated upon had been given systematic physical therapeutics over a period of two years, with so little result that the parents turned to operation as a last resort. The results were a great improvement over anything obtained by the previous efforts.

If the operative technique and after-treatment are properly carried out the results will always be worth the trouble.

Instead of publishing a long list of case histories I shall illustrate the value of operation by detailing one case, with serial photographs, in which the entire result must be credited to the surgical interference because there had been complete rupture of the plexus, and there had been absolutely no spontaneous improvement during the year of life.

Ruth F. (Case 9 of my series), aged one year.

History. She was the second child of the family, was large, and was delivered with instruments after a difficult labor. Soon after birth it was noticed that the left upper extremity was lifeless. There has never been any improvement in it in spite of intermittent treatment received in various clinics. Except for the arm she has been perfectly well.

Examination. She is a large, well-nourished child, normal except for the left upper extremity, which hangs lifeless by her side (Fig. 7). There is some power in the serratus magnus, contraction of which, with some contortion of the trunk, throws the extremity slightly forward. The soft tissues are flabby and the extremity is cold. The muscles show reaction of degeneration. A large indurated mass can be felt on the left side of the neck at the site of the brachial plexus.

Operation. June 8, 1905. Ether anesthesia. The plexus was exposed by the usual dissection. The deep fascia was thick and adherent to the front of the whole plexus, which was itself one large mass of cicatricial tissue, with the nerve roots running into it above and the nerve trunks coming off from it beneath the clavicle. The roots were divided above the cicatricial mass nearly at the foramina. The plexus was removed *en masse* by dividing the nerve trunks as they emerged from its distal end beneath the

clavicle. In attempting end-to-end suture the nerve ends could be approximated to within only 2 cm. of each other, so loops of chromic gut (No. 1, 40 day) were passed through the roots and distal trunks and surrounded *en masse* with cargile membrane. The suprascapular nerve was carefully included in the suture. The wound was closed without drainage and the head and neck bound in close approximation. This fixation was maintained six weeks. (At the present time I should hold the position for at least twelve weeks, which I could easily do with the steel brace.) The reaction was good. Primary union resulted.



FIG. 7.—Rupture of the entire plexus on the left side. Note the completely paralyzed, flaccid hang of the left extremity while she is playing with something in the right hand.

Postoperative History. This child was brought for examination only at irregular and infrequent intervals. At the end of three months the muscles were more flabby than ever, the shoulder was a flail-joint, and there was no sign of returning power.

December 21, 1905, six months after operation, the mother first noticed that the terminal joints of the thumb and index, middle, and ring fingers were swollen, glossy, red, and ulcerated on the tips. They were not sensitive and were not infected. They remained in this condition for about six weeks, and then gradually the fingers improved, until, on May 21, 1906, they were almost normal again.

While this trophic disturbance was present in the digits, there

was, on December 21, 1905, distinct but slight activity in the pectoralis major, triceps, and serratus muscles.

May 21, 1906 (one year less eighteen days), the movement in the above muscles was stronger. There also appeared some power



FIG. 8.—Eleven and one-half months after operation.



FIG. 9.—Same as Fig. 8. Lying on her back she is able to raise the arm perpendicularly. in the deltoid, both for anterior elevation of the arm and slightly for abduction (Fig. 8). There was also slight power of flexion at the wrist. When she was lying supine she could elevate the entire extremity to a perpendicular with the floor without much effort

(Fig. 9). At this time there was distinct contracture of the flexor muscles of the fingers. The mother had neglected the massage. The shoulder had lost its flail-like character and the muscles of the whole extremity were firmer.

October 27, 1907 (two years and four months). The flexion contracture of the fingers had entirely disappeared. She had been using the extremity freely for the preceding six months,



FIG. 10.—Sixteen and a half months after operation. Note the improved size and position of the hand and arm.



FIG. 11.—Same as Fig. 10. Voluntary flexion at the elbow with some supination of the forearm.

handling playthings, feeding herself with it, etc. All of the muscles showed some return of voluntary power, although the flexors of the fingers and extensors of the radial carpus were quite feeble. The extremity had grown very well.

February 4, 1908 (two years and eight months). Marked improvement in all the movements of the extremity. She can put the hand to the mouth easily. There is fairly strong flexion and extension of all the digits.

February 1, 1910 (four years eight months). Marked increase in power of muscles. Can do things with the separate fingers.

February 7, 1911 (five years eight months). Marked increase in power and definite control of the muscles. The whole extremity is smaller than the right one.

SUMMARY. The essential etiologic factor consists in the forcible separation of the head and neck from the shoulder on the side of the lesion.



FIG. 12.—Same as Fig. 10. Anterior elevation of the extremity so that wrist is at the level of the hair line. The hand is still useless.



FIG. 13.—Same as Fig. 10. Abduction at the shoulder showing activity of the deltoid.

Pathology. The deep cervical fascia, the nerve sheaths, the nerves, and small accompanying vessels are torn. After a time the resulting blood-clot and torn structures form a dense cicatrix which prevents nerve regeneration. As a rule the injury involves the roots in order from above downward, and may vary in extent from a slight injury of the upper root to a complete rupture of the entire plexus. In some cases roots are torn from the cord itself. Secondary pathologic changes occur in the muscles, ligaments, and joint-ends of the bones.

Symptoms. The paralyzed muscles fall into groups according to the roots injured. The characteristic attitude is one of marked inward rotation of the whole extremity, which is accentuated by the pronation of the forearm and hand. There is always some posterior displacement of the upper end of the humerus as compared with the normal side, and in a small proportion of cases there is complete posterior dislocation of the shoulder. Sensory disturbances are slight and usually soon disappear. Interference with growth



FIG. 14.—Three years after operation. Showing growth of arm and hand.



FIG. 15.—Same as Fig. 14. Showing sufficient strength to support a large heavy doll upon the forearm and hand.

is always present and is most marked about the shoulder girdle. Deformity usually increases with age. A cicatrix can easily be felt in the region of the damaged nerves, and is usually tender even after years.

Prognosis. Prognosis is bad. There is nearly always some degree of deformity and paralysis which persists.

Operation. Operation gives the best prospect for a useful arm. The best time for operation is as early as the general condition of the individual patient will permit (three to twelve weeks). In

the few cases in which complete spontaneous recovery will occur the paralysis is usually not extensive, improvement starts early and continues rapidly, and operation is evidently contraindicated. In debatable cases operation really amounts to early exploration, with repair of such damage as may be found. There is exceedingly little danger to the operation, which amounts only to an incision through the skin and fat at the base of the neck.



FIG. 16.—Same as Fig. 14. A light rubber doll grasped in the hand (that is, lifted from a chair by the left hand) and held forward of the body with the elbow flexed. This child had a complete rupture of the plexus and complete flaccid paralysis of the whole extremity.

Up to the time of operation the extremity should be held up in a sling to take its weight off the damaged nerves and paralyzed muscles.

In the cases where roots have been torn from the cord they must be laterally implanted into the neighboring roots, or if the neighboring roots have been damaged enough to require resection all of the distal nerve trunks may be sutured in a bunch to the proximal roots still attached to the cord.

After operation the head and shoulder must be held in approximation for weeks by a steel brace fitted before operation.

After-treatment must be systematic and persistent.

Results will never be perfect, but operation will give improvement much greater than that obtainable by any other method.